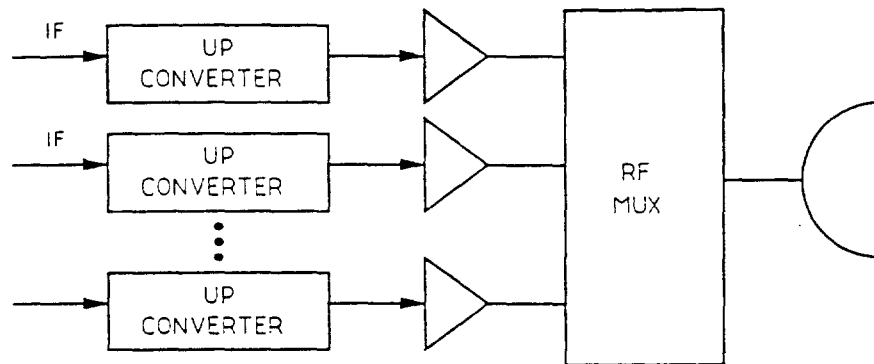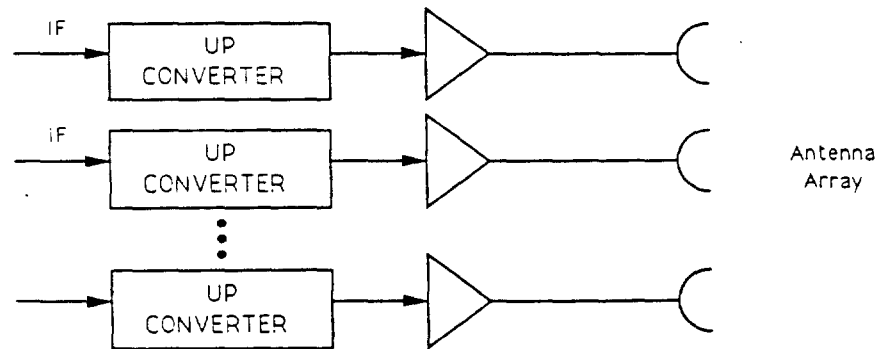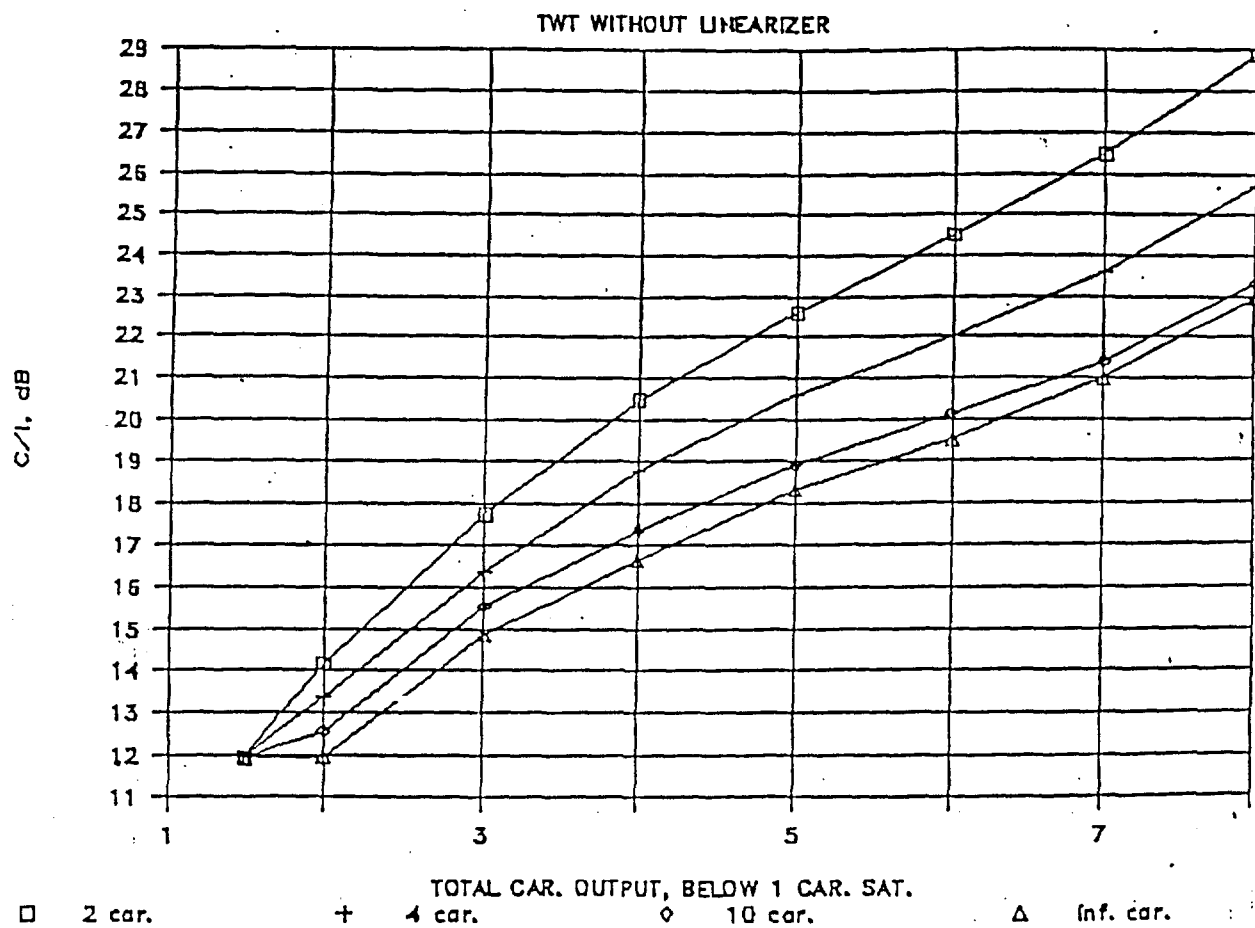Figure II-3.1 Transmitting System Options

Figure II-3.2 Multiple carrier intermodulation.

4. FM Repeaters

Solid-state low cost repeaters will be used to provide coverage to shadow areas (Fig II-4.1). The signal polarization in the links between the repeater and subscribers will be polarized opposite to those in the links between headend and repeaters. Tables II-4.1 to II-4.5 give some examples of video signal power requirement at a repeater for distribution within the repeater coverage area. These tables represent a worst case calculation because they assume the repeater is positioned at the extreme edge of the transmitter's coverage area. Repeaters closer to the transmitter can have coverage areas of up to 2 miles with the same power level requirements. The repeater-to-subscriber power is adjusted to provide the appropriate coverage. In addition, proper shaping of the transmitting antenna for a given location will greatly enhance the range or coverage area. It is seen that the amplifier power requirement for 50 channels is low. For instance, at New York a repeater which can deliver 6 dBm power per FM carrier can provide a coverage of 0.75 miles, when placed at the edge of a transmitter's coverage area, and 2 miles of coverage when placed halfway to the edge. The repeater involves frequency translations (RF to IF, IF to RF) and signal amplification. Frequency control of the oscillators can be done using pilots.

Passive repeaters using reflectors can be used to propagate the signal down the sides of a building or to reach nearby shadow areas without polarization reversal. Higher gain passive repeaters can be used with a dual antenna system and may require polarization reversal.

Table II-4.1

Suite 12 Video Distribution System Link Analysis for Repeaters
City: New York

		Repeater-to-subscriber path length (miles)	
		0.25	0.75
1.	Repeater RF amplifier power[1] per FM channel, dBm	-3.0	6.0
2.	Transmitting antenna feed loss, dB	1.0	1.0
3.	Transmitting antenna gain[2], dBi	18.0	18.0
4.	Free space loss (at 28 GHz), dB	113.5	123.0
5.	Receiver dish antenna diameter, inches	7.5	7.5
6.	Receiver antenna gain, dBi	32.0	32.0
7.	Boltzmann's constant, dBW/K/Hz	-228.6	-228.6
8.	Bandwidth (18 MHz), dB-Hz	72.6	72.6
9.	Receiver noise temperature, dBK	29.5	29.5
10.	Repeater-to-subscriber link CNR[1], dB	29.0	28.5
11.	Rain rate for 0.01% mm/hr	52.4	52.
12.	Rain attenuation (99.9% availability), dB	1.5	4.3
13.	Rain faded CNR[3], dB	27.5	24.2
14.	Headend-to-repeater distance, miles	3.9	3.9
15.	Headend-to-repeater link CNR[3] in clear weather, dB	36.2	36.2
16.	Headend-to-repeater link faded CNR[3], dB	17.6	17.6
17.	Rain faded CNR, from headend to subscriber[4],dB	16.4	16.0
18.	Video Receiver Transfer Function, dB	29.0	29.0
19.	Clear weather Video SNR, dB	51.6	51.5
20.	Rain faded SNR, dB	45.4	45.0

---

[1] Solid state power amplifiers with single carrier saturating power values of 0.2 W and 1 W, operating at 5 to 6 dB output backoff assumed for -3 and 6 dBm cases, respectively.

[2] Covers a sector of 45°

[3] Excluding intermodulation noise. Repeater receive antenna gain is 42.0 dBi (24 inch dish).

[4] Includes intermodulation noise produced by the transmitter and repeater amplifiers. The C/IM is taken to be 24.0 dB

Table II-4.2

Suite 12 Video Distribution System Link Analysis for Repeaters

City: Boston

		Repeater-to-subscriber path length (miles)	
		0.25	0.75
1.	Repeater RF amplifier power[1] per FM channel, dBm	-3.0	6.0
2.	Transmitting antenna feed loss, dB	1.0	1.0
3.	Transmitting antenna gain[2], dBi	18.0	18.0
4.	Free space loss (at 28 GHz), dB	113.5	123.0
5.	Receiver dish antenna diameter, inches	7.5	7.5
6.	Receiver antenna gain, dBi	32.0	32.0
7.	Boltzmann's constant, dBW/K/Hz	-228.6	-228.6
8.	Bandwidth (18 MHz), dB-Hz	72.6	72.6
9.	Receiver noise temperature, dBK	29.5	29.5
10.	Repeater-to-subscriber link CNR[1], dB	29.0	28.5
11.	Rain rate for 0.01% mm/hr	49.0	49.0
12.	Rain attenuation (99.9% availability), dB	1.4	3.9
13.	Rain faded CNR[3], dB	27.6	24.6
14.	Headend-to-repeater distance, miles	4.1	4.1
15.	Headend-to-repeater link CNR[3] in clear weather, dB	35.7	35.7
16.	Headend-to-repeater link faded CNR[3], dB	17.7	17.7
17.	Rain faded CNR, from headend to subscriber[4],dB	16.4	16.1
18.	Video Receiver Transfer Function, dB	29.0	29.0
19.	Clear weather Video SNR, dB	51.6	51.5
20.	Rain faded SNR, dB	45.4	45.1

---

[1] Solid state power amplifiers with single carrier saturating power values of 0.2 W and 1 W, operating at 5 to 6 dB output backoff assumed for -3 and 6 dBm cases, respectively.

[2] Covers a sector of 45°

[3] Excluding intermodulation noise. Repeater receive antenna gain is 42.0 dBi (24 inch dish).

[4] Includes intermodulation noise produced by the transmitter and repeater amplifiers. The C/IM is taken to be 24.0 dB

Table II-4.3

Suite 12 Video Distribution System Link Analysis for Repeaters
City: Chicago

		Repeater-to-subscriber path length (miles)	
		0.25	0.75
1.	Repeater RF amplifier power[1] per FM channel, dBm	-3.0	6.0
2.	Transmitting antenna feed loss, dB	1.0	1.0
3.	Transmitting antenna gain[2], dBi	18.0	18.0
4.	Free space loss (at 28 GHz), dB	113.5	123.0
5.	Receiver dish antenna diameter, inches	7.5	7.5
6.	Receiver antenna gain, dBi	32.0	32.0
7.	Boltzmann's constant, dBW/K/Hz	-228.6	-228.6
8.	Bandwidth (18 MHz), dB-Hz	72.6	72.6
9.	Receiver noise temperature, dBK	29.5	29.5
10.	Repeater-to-subscriber link CNR[1], dB	29.0	28.5
11.	Rain rate for 0.01% mm/hr	52.0	52.0
12.	Rain attenuation (99.9% availability), dB	1.5	4.3
13.	Rain faded CNR[3], dB	27.5	24.2
14.	Headend-to-repeater distance, miles	3.9	3.9
15.	Headend-to-repeater link CNR[3] in clear weather, dB	36.2	36.2
16.	Headend-to-repeater link faded CNR[3], dB	17.8	17.8
17.	Rain faded CNR, from headend to subscriber[4],dB	16.5	16.1
18.	Video Receiver Transfer Function, dB	29.0	29.0
19.	Clear weather Video SNR, dB	51.3	51.2
20.	Rain faded SNR, dB	45.5	45.1

---

[1] Solid state power amplifiers with single carrier saturating power values of 0.2 W and 1 W, operating at 5 to 6 dB output backoff assumed for -3 and 6 dBm cases, respectively.

[2] Covers a sector of 45°

[3] Excluding intermodulation noise. Repeater receive antenna gain is 42.0 dBi (24 inch dish).

[4] Includes intermodulation noise produced by the transmitter and repeater amplifiers. The C/IM is taken to be 24.0 dB

Table II-4.4

Suite 12 Video Distribution System Link Analysis for Repeaters

City: Los Angeles

		Repeater-to-subscriber path length (miles)	
		0.25	0.75
1.	Repeater RF amplifier power[1] per FM channel, dBm	-3.0	6.0
2.	Transmitting antenna feed loss, dB	1.0	1.0
3.	Transmitting antenna gain[2], dBi	18.0	18.0
4.	Free space loss (at 28 GHz), dB	113.5	123.0
5.	Receiver dish antenna diameter, inches	7.5	7.5
6.	Receiver antenna gain, dBi	32.0	32.0
7.	Boltzmann's constant, dBW/K/Hz	-228.6	-228.6
8.	Bandwidth (18 MHz), dB-Hz	72.6	72.6
9.	Receiver noise temperature, dBK	29.5	29.5
10.	Repeater-to-subscriber link CNR[1], dB	29.0	28.5
11.	Rain rate for 0.01% mm/hr	30.0	30.0
12.	Rain attenuation (99.9% availability), dB	0.8	2.4
13.	Rain faded CNR[3], dB	28.2	26.1
14.	Headend-to-repeater distance, miles	6.0	6.0
15.	Headend-to-repeater link CNR[3] in clear weather, dB	32.4	32.4
16.	Headend-to-repeater link faded CNR[3], dB	17.1	17.1
17.	Rain faded CNR, from headend to subscriber[4], dB	16.0	15.8
18.	Video Receiver Transfer Function, dB	29.0	29.0
19.	Clear weather Video SNR, dB	51.3	51.2
20.	Rain faded SNR, dB	45.0	44.8

---

[1] Solid state power amplifiers with single carrier saturating power values of 0.2 W and 1 W, operating at 5 to 6 dB output backoff assumed for -3 and 6 dBm cases, respectively.

[2] Covers a sector of 45°

[3] Excluding intermodulation noise. Repeater receive antenna gain is 42.0 dBi (24 inch dish).

[4] Includes intermodulation noise produced by the transmitter and repeater amplifiers. The C/IM is taken to be 24.0 dB

VERTICAL
POLARIZATION

BUILDING

HORIZONTAL
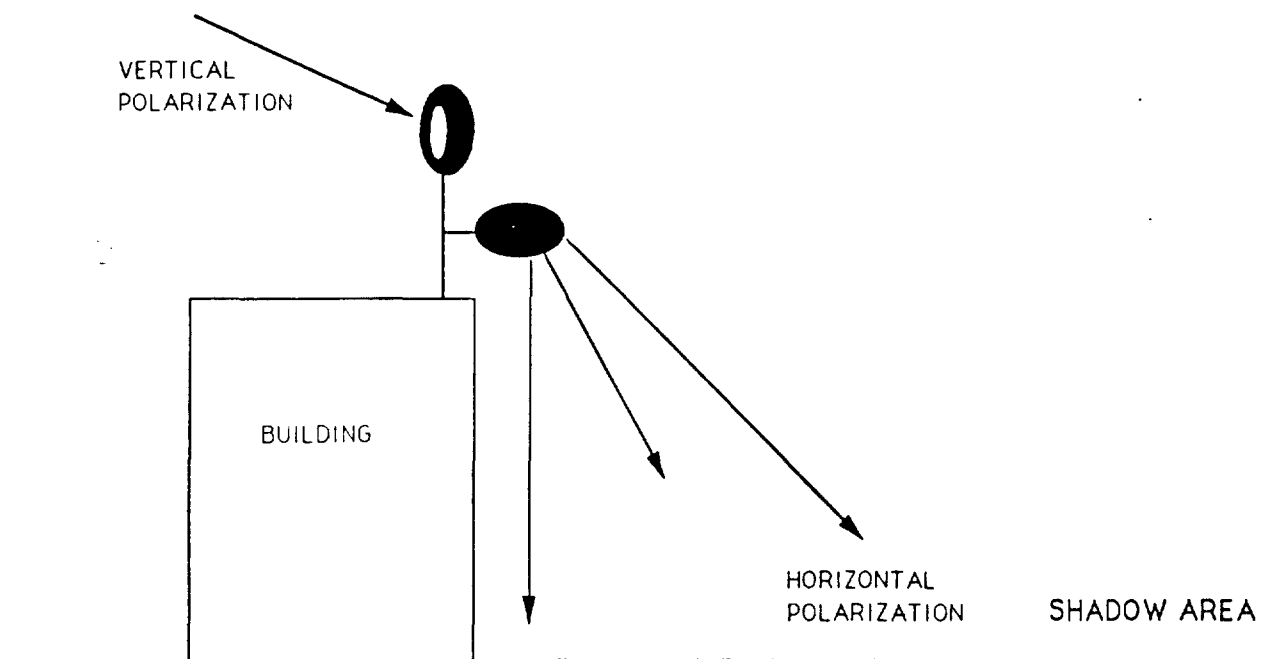POLARIZATION

SHADOW AREA

Figure II-4.1   Signal transmission for shadow areas.

5.   FM Receiver

The receiver unit consists of a microwave frequency converter which converts the RF signal in 27 to 29 GHz range to an IF, typically, in the range of 950 to 2000 MHz. The details of the microwave converter will not be described here. The indoor unit converts the IF to the TV baseband, or a VSB AM signal at channel 3. The IF signal processor can be implemented in a variety of ways, and is essentially a DBS satellite receiver. Figures II-5.1 to II-5.5 show the principles, which are taken from a Philips' reference (Electronic Components and Applications, Vol. 9, No. 3). The system shown has IF in the range of 950 to 1750 MHz, which is standard for European satellite receivers. For the present application the principal difference is in the number of channels, their center frequencies (set by a micro or a PROM), and the IF SAW filter bandwidth. Many of the European DBS receivers are equipped with SAW filters that can be selected to 27 or 18 MHz bandwidth, which agree with the 27 and 20 MHz cases considered in earlier sections.

At least one European manufacturer has intimated to us that hardware for IF in 950 to 2050 MHz can be made available to Hye Crest. Clearly, this will let Hye Crest permit the full usage of the 1 GHz band.

The cost of the IF processor is essentially independent of the number of channels. Units at a price of $200 per unit, in quantities of 5,000, have been quoted. If a mark-up of 20 to 40% by the manufacturer is removed, the real cost of chips and manufacturing would be in the range of $120 to $160. This does not include costs of descrambling and conditional access and pay-per-view features.
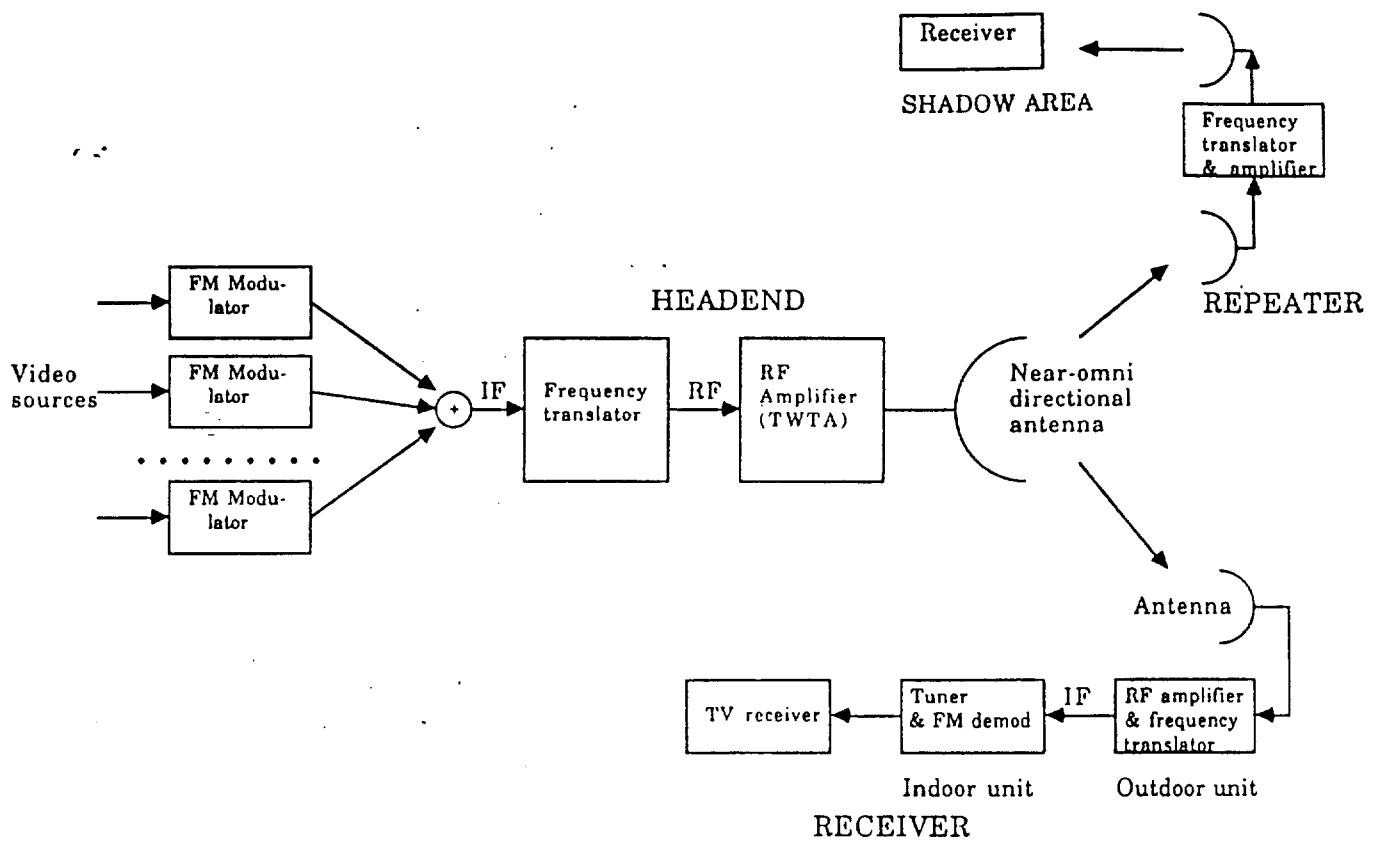
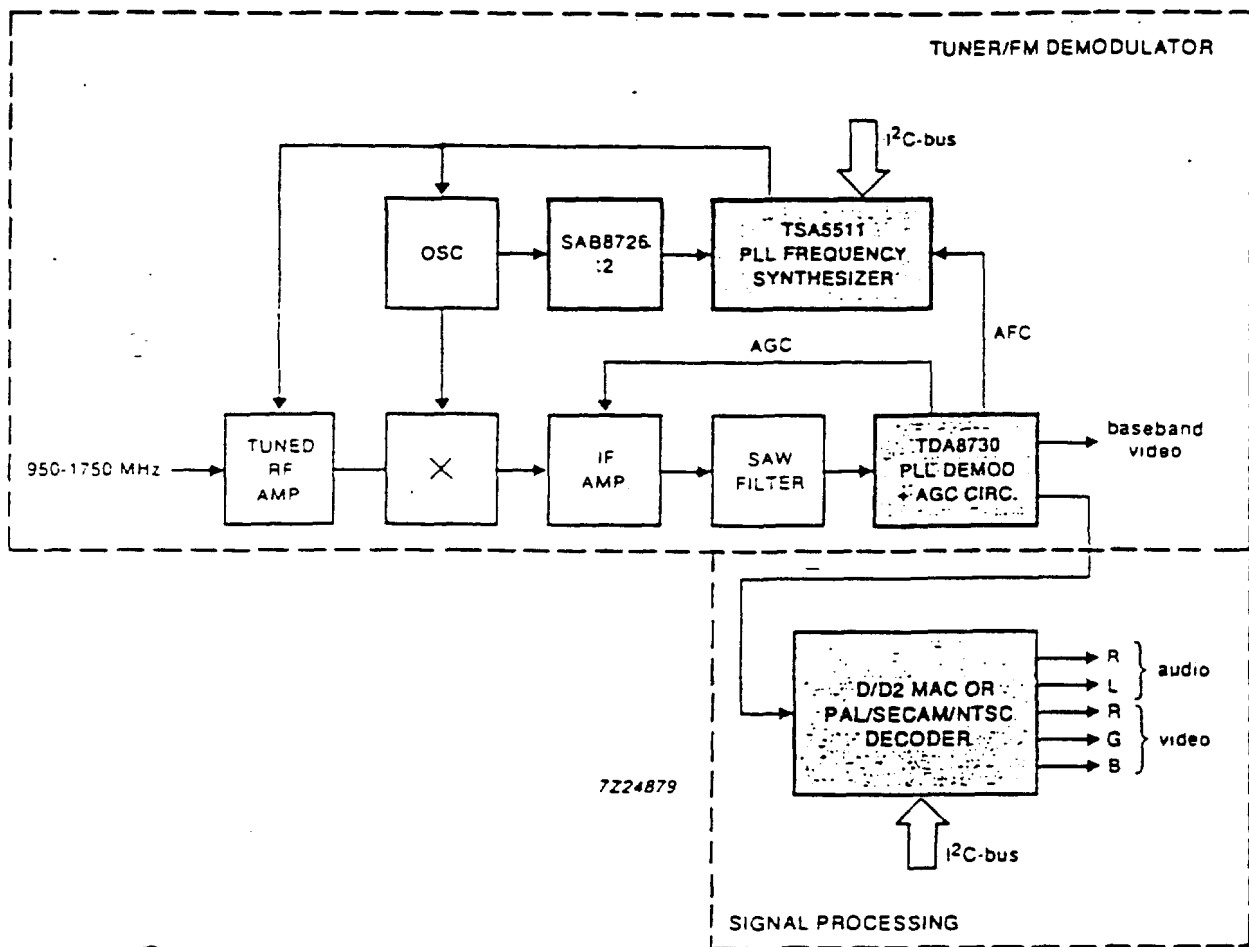Figure II-5.1   CellularVision system principles.

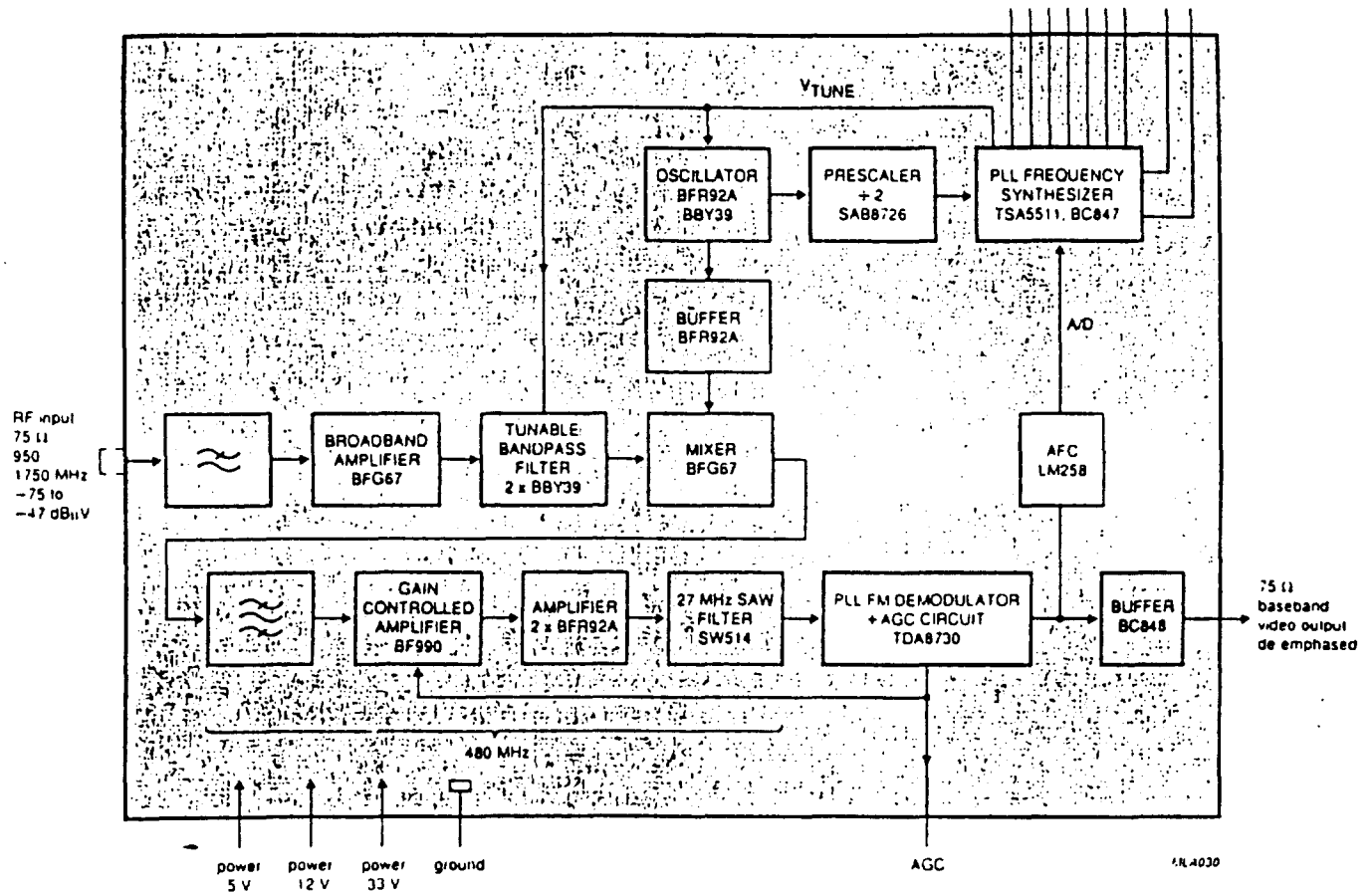Figure II-5.2 Indoor unit of a satellite TV receiving system.
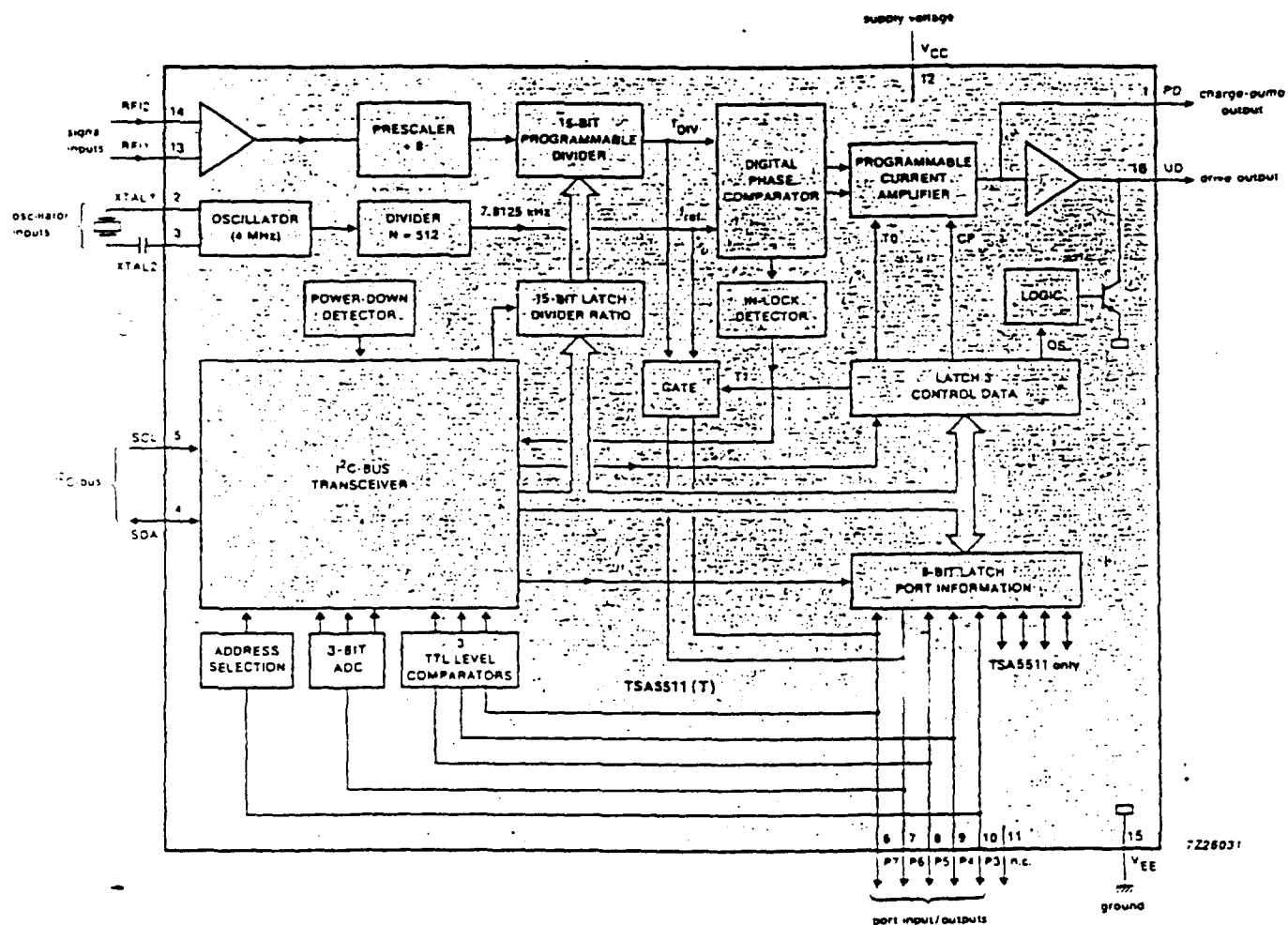
Figure II-5.3   Tuner/FM demodulator.

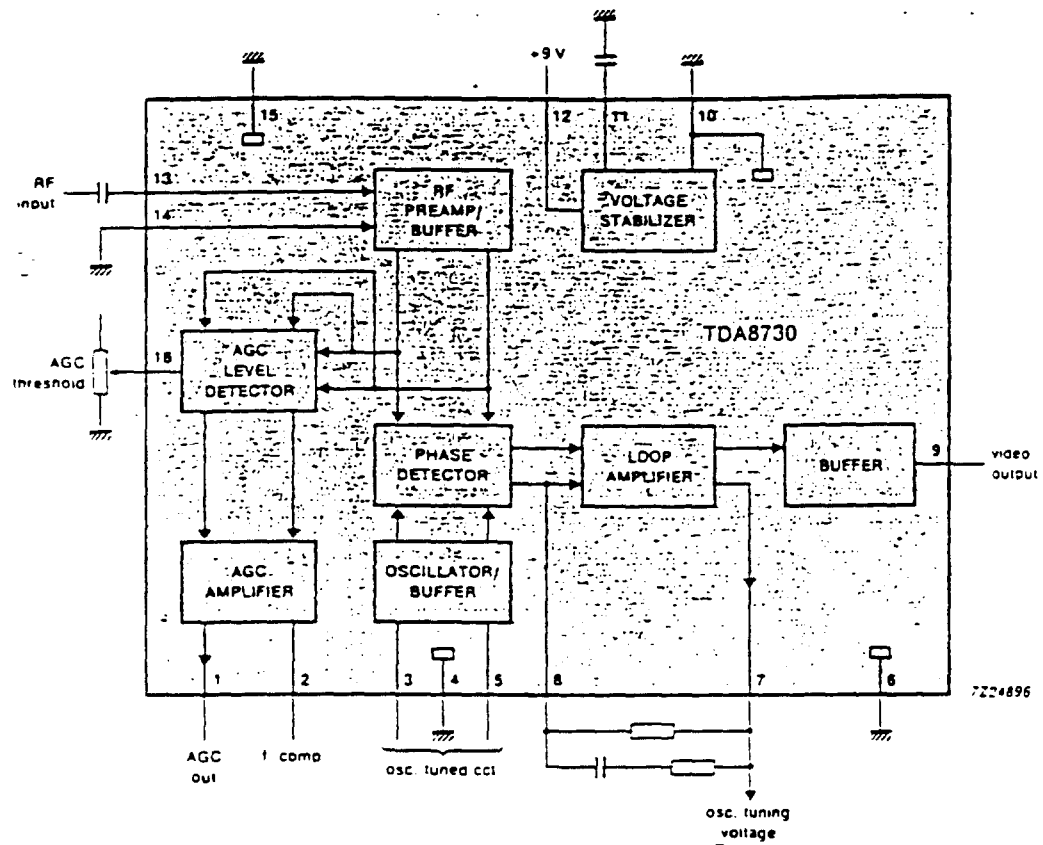Figure II-5.4   The TSA5511 PLL frequency synthesizer.

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Figure II-5.5   The TDA8730 PLL FM demodulator and AGC.

6.   Polarization and Frequency Re-Use

Interference between video distribution signals and two-way communication signals within the same cell and signals in nearby cells is eliminated by the innovative use of frequency diversity, space diversity, antenna polarization, and the FM strong signal capture effect.

The video distribution signals and two-way communication signals are transmitted from each node with orthogonal polarizations. The video signals are contiguously spread across the frequency spectrum with carrier separations of 20 MHz. The two-way communication signals are grouped together into channels which are centered at the edges of the video channels. That is, the center of the two-way communication channels are offset by 10 MHz from the video carriers. The combination of frequency offset and cross-polarization provide 40 dB of effective isolation between video and two-way communication signals at the subscriber's receiving antennas.

The polarization of the signals in adjacent cell node transmitters are reversed. Any subscriber receivers which are located in the fringe area between adjacent cells will be protected from adjacent cell interference because this polarization reversal provides 25 dB of isolation from adjacent cell signals. Additional isolation is provided by the narrow beamwidth subscriber's receiving antenna which is pointed toward its own cells transmitting node. Additional remarks on interference can be found in Appendix 3.

7.   Initial System Plan

Based on this study, we can conclude that the cellular system shall be an FM based video distribution. With a 100 W transmitting amplifier, cell diameters of up to 6.0 miles can be supported at New York if FM channels with 20 MHz spacings are used; this assumes that 1 GHz bandwidth will be allocated for

transmission, corresponding to 49 channels with the 20 MHz spacings and frequency offset interleaving of 10 MHz. The transmitting station should be equipped with a (near) omni directional antenna with a minimum 10 dBi gain. This antenna can be realized with a doughnut shaped gain pattern, rather than a hemispherical pattern. The transmitting amplifier backoff of 7 dB is assumed for this service. At the receiver, a 7.5 in. dish antenna with 32 dB gain, and Noise Figure of 6 dB should be employed. No specific recommendation on receiver IF is made, except that 950-2050 MHz appears to be attractive; standard value in European DBS receivers is 950-1750 MHz, which has been extended to 2050 MHz.

It is recommended that scrambling of the video channels be implemented. We estimate that simple, yet reasonably effective methods, can be included in the receiver at a cost of $30 to $50. Sophisticated hard to defeat systems can be included at a cost of $75 to $100 per receiver.

8. Long Term Options

In the long term, effort should be made to introduce digital video transmission using QPSK modulation whenever costs are reduced to a point where cable and fiber optic systems are in the process of deploying this technology. This will permit a four-fold increase in capacity, for all systems and will allow wireless to remain in competition with hardwired video delivery methods (e.g. coaxial and fiber optic cable). Further, this is the only way HDTV can be delivered to viewers.

The QPSK modulation is one example of digital modulation. Other possible candidates are MSK and GMSK, which have a data transmission efficiency of 1.3 to 1.5 bits/Hz. Unlike QPSK, MSK and GMSK have a constant envelope and hence are attractive for application here.

To select the best digital modulation, it is recommended that experimental effort begin as soon as possible. Since successful widespread implementation of digital video transmission will not occur for about two years or more, reasonable lead time is available.

Successful digital video transmission obviously requires inexpensive video decompression hardware. There is a high probability that the terrestrial HDTV standard (to be decided by the FCC in 1 1/2 to 2 years) will be modified for standard definition TV transmission by the developers for use on satellite and cable channels. At least one of the HDTV proponents already has such a unified approach, using the same receiver hardware for all the three applications. Since this will be a part of future TV receivers, Hye Crest will need to provide only transmission hardware, along with conditional access features. The video decompression will be a part of the TV receiver. At this point in time this is an optimistic prediction, but is only one of several possible scenarios. For example, there is no guarantee that the satellite and cable transmission standard will necessarily be like that of the terrestrial standard, although it would be advantageous to consumers to have such a unified standard. In any event, this hardware, if it proves to be economically feasible, could improve both the cable, fiber optic, and MLDS systems.

9.   **Other Modulation Methods**

a) <u>Spread spectrum systems.</u> These are useful when a strong interference can be expected from an external source, which is not true here. Consequently, no advantage can be expected from such a modulation, especially for broadcast services. Further, a high speed (e.g., 5 Mbps data rate spread over 800 MHz) spread spectrum receiver is complex to implement. In addition, as in any data

link, one needs video compression and decompression hardware, which is expensive and not readily available.

b) Digital FM and variations. A method of transmitting data as the baseband of FM, and using discriminator detection was described earlier. Slightly higher efficiency (lower transmitted power, smaller bandwidth, or, lower bit error rate) can be obtained in other forms of FM data modulation. Coherent detection, which is substantially more complicated than discriminator detection, leads to the increased efficiency, but is expensive to implement. This is not recommended for the Suite 12 system..

c) Amplitude Modulation (AM). The use of AM for video distribution may seem attractive because each channel requires only 6 MHz of bandwidth and a FM demodulator is not required. But an analysis of the system indicates serious disadvantages and unsurmountable problems. The transmitter power requirements at 28 GHz, for the required cell diameters, are far beyond the state-of-the-art. This is a result of the more stringent CNR and linearity requirements.

Repeaters, required for shadow area coverage, for AM systems cannot be used for the same reasons. Two-way communications cannot be used because of technical limitations on dynamic range requirements, the required subscriber transmitter power, and insufficient isolation.

It was shown earlier that FM transmission can give acceptable signal transmission range even with relatively low transmitter powers. The primary reason is that the (rain faded) CNR required for FM is low (13 dB in 20 MHz). The corresponding carrier-to-noise density ratio, C/No, is 86 dB-Hz. For AM the rain faded SNR(TASO) should be 42 dB. The corresponding C/No for AM is 109.8 dB-Hz. Hence an AM transmitter requires 23.8 dB more power per carrier. In Tables I-5.3 to I-5.7, the transmitter output power for a single FM carrier is 0.4W. For AM transmission this needs to be increased to 96W of output power for a

single carrier, assuming that all other parameters (antenna gains) are unchanged.

When more than one channel is transmitted, the cases for AM becomes even worse. Considering the same system parameters, but now transmitting 49 channels of FM, the TWTA used for the transmitter must have a power rating of 98 watts. This can be calculated by multiplying the output power for each channel (-4 dBW - 0.4 W) by 49 and increasing the transmitter power by the required multichannel backoff for FM (7 dB).

The power rating for a TWTA used in an AM system can be calculated in a similar manner. In this case the required backoff is 15 to 20 dB (15 dB is used). The required TWTA power is 148.7 Kilowatts which is completely unrealistic. In the AM case, even if a single channel is transmitted, 15 to 20 dB backoff is required. This is due to the fact that intermodulation distortion products generated by the picture, color, and sound carriers must be 50 dB below the picture carrier level at the peak of sync. This means that the power rating for a TWTA transmitting a single channel of AM must be 3 Kilowatts.

If the same transmitting tube is used for FM or AM, the transmitting range for AM is greatly reduced. A TWTA rated at 96 watts used in a 49 channel system will have a clear weather cell radius of only 0.7 miles for AM. With FM this range is extended by a factor of 22 or 15 miles.

With AM transmission, repeaters cannot be implemented economically. Wideband repeater amplifiers, that can amplify all of the AM signals, will either introduce too much intermodulation noise, or will be required to be operated at a very high backoff, and consequently must have several Kilowatts of power rating. Filtering each channel and employing one amplifier per channel is not feasible since it would require filter Q's which are unattainable. The implication is that coverage for shadow areas will be impossible. In the FM based transmission this

is unnecessary, since the central nodes of all the cells, except one master station, can simply act as high quality repeaters consisting of block conversion and amplification. Low level solid state repeaters are available for FM shadow area reception.

Since AM signals are extremely intolerant to interference, the (C/I values range from 45 to 55 dB), the spectral ban occupied by the AM signals cannot be used for any point-to-point or two-way links within a cell.

Return transmissions from the subscriber transmitter also require much higher power levels for AM then FM. Technologically this represents several problems: higher costs for subscriber transmitters and interference. Interference occurs between near by subscribers because the isolation requirements are much more stringent for AM then for FM (C/I of 15 dB for FM, C/I of 55 dB for AM). In addition, the dynamic range requirements, located at the node, of the receiver which is picking up the transmission from the subscribers represents a formidable technological problem. It must be capable of detecting very low level signals at the same location in which Kilowatt level signals are being broadcast.

Of all the modulation candidates studied, 20 MHz FM is the recommended candidate for very high quality TV multichannel distribution. It allows the combined use of polarization, frequency diversity, spacial diversity to optimize the use of the 1000 MHz frequency spectrum. It provides the simultaneous capability of TV distribution and two-way communications.

10. Interference Between Video Distribution and Point-to-Point Services

Suite 12 point-to-point terrestrial links can co-exist with Suite 12 video signals provided certain conditions are met. The line-of-sight of a point-to-point link should not go through the Suite 12 video central transmitter location. The point-to-point link receiver and transmitter dish diameter should be as large as

possible, so that the its beamwidth is small and will offer even further reduction of interference signals from the Suite 12 video central transmitter.

We will first consider interference from the Suite 12 video system into a point-to-point link. The goal here is to give an example that a properly designed point-to-point link can co-exist with the Suite 12 video system and may be used as a backbone network for Suite 12.

Consider the Suite 12 video omni directional transmitter and a point-to-point link, shown in Figure II-10.1. Let "C" be the Suite 12 video transmitter location with a G_t = 10 dB omni directional antenna gain, P_t = 100 W transmitting amplifier, operating with 7 dB of output backoff (OBO), and F2 = 1 dB of feed loss. Let "B" be the transmitting system of the Suite 12 point-to-point link, and "A" be the receive side of this point-to-point link. This receiver has a noise figure of NF = 6 dB, for reception of a signal over bandwidth B (MHz). The minimum CNR of this link is denoted by CNRMIN, and is taken to be 10 dB. Then the wanted signal carrier power at "A" is

$$C = CNRMIN + [-228.6 + 10 \log B + 60 + 10 \log(300(10^{0.1NF} - 1))]$$

where the quantity in the square parentheses is the received noise power. The unwanted signal power in bandwidth B is given by

$$I = P_t(dBW) - OBO - FL + G_t - L + 10 \log(B/B_t) - XPOL + G_r(\theta)$$

where

B_t is the bandwidth of the emitted signal at "C", in MHz (1000 MHz)

XPOL   is the cross-polarization advantage

G_r is the on-axis gain of the receiver antenna at "A", in direction of "B", in dB

$G_r(\theta)$ is the off-axis gain of the antenna at "A" in the direction of the Hye Crest antenna "C"

From these quantities C/I can be computed. If it is assumed that at receiver "A" the interference level should be 3 or more dB lower than the noise level, the relation between the link parameters can be obtained by setting N/I $\geq$ 3 dB. For the assumed parameters here this is equivalent to

$$20 \log D + XPOL - G_r(\theta) \geq 8.56, dB$$

In the point-to-point link the receiving antenna need not be small, since it is not a consumer distribution system. We can assume a 15" receiver antenna, which has:

$$G_r = 38 \, dB$$
$$G_r(5 \, deg) = 14 \, dB$$
$$G_r(10 \, deg) = 9 \, dB$$

The off-axis gain is 1 to 3 dB more pessimistic than the rule-of-thumb values of 31 - 25 log θ. Assuming that in clear weather an XPOL value of 25 dB is achievable, we arrive at

$$20 \log D \geq -2.44 \text{ for } 5° \text{ separation}$$

or

$$D \geq 0.75 \text{ miles}$$

If XPOL is only 20 dB, D should be at least 1.34 miles, with 5° separation. These values can be improved if the point-to-point link has FM video. Such a link can be frequency offset from the Hye Crest FM carriers by 1/2 carrier separation. For such a separation we can assume an offset advantage of at least 20 dB. Hence D is 0.075 mile (400 ft), or 0.13 mile (709 feet) depending upon the XPOL of 25 or 20 dB respectively.

Consider next interference from the point-to-point link into the Hye Crest system. Since the Hye Crest is a broadcasting system, a large number of receivers will be located within the coverage area. The area of the coverage region that cannot be used for Hye Crest receivers is no more than a small fraction of the total

area. With a pessimistic degree of approximation this is far less than 1%. Such areas can be covered for the Hye Crest customers with a passive repeater located such that the receiver antennas can be directed completely away from the interfering source.
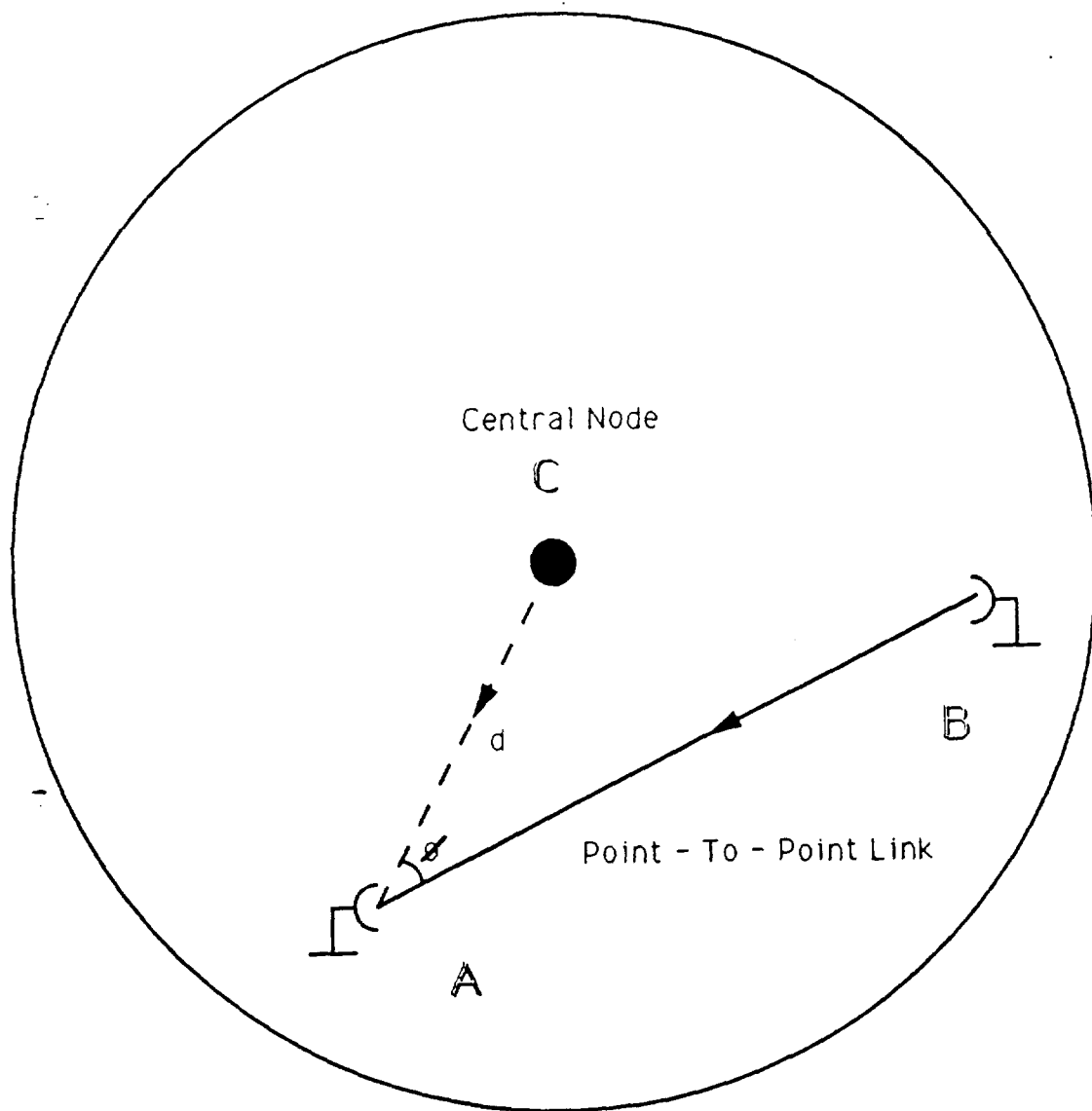

Figure II-10.1 Coexistence of the video links and point-to-point links.

Section III
Secondary Services

1. Introduction

An additional feature of the system is the future development of two-way links between the headend and subscribers. These will be used for telephone, computer data transmission, office business traffic generated from PBXs, and digital video services such as teleconferencing. A number of important requirements should be met for technical and economical viability of such a communication network. Foremost among them is the requirement that the subscriber RF and baseband equipment must be inexpensive and should be capable of receiving and transmitting signals of adequate power and bandwidth. On the RF side, transmission systems that can generate 10 to 15 dBm of power are economical to implement, and are shown here to be adequate to meet the communication requirements. For baseband signal processing systems the cost depends upon volume of production; hence choosing a system which is either an established, or an evolving, standard is essential. It is shown that such a constraint can be met.

For telephone services, FM carriers of 30 KHz bandwidth may be used initially with analog baseband. Such channels in a frequency division multiplexed mode can be fixed assigned to users, or demand assigned using a control channel, depending on the total number of circuits required. Demand assignment hardware can be inexpensively implemented using terrestrial cellular radio hardware. Since up to 15,000 telephone circuits capacity exists in the 1 GHz frequency band, the decision to use fixed or demand assigned circuits will depend upon the expected number of telephone users in the system. The demand assigned telephone circuits can be analog (or digital on the long run), using cellular radio standards.

For data services, constant or near constant envelope modulation may be used. Modulation methods, such as π/4-QPSK or GMSK, produce low out-of-band energy when transmitted through the nonlinear RF transmitting amplifier at the subscriber's premises in the subscriber-to-headend link. For instance, for digital video of teleconference quality a 200 KHz GMSK channel transmitting 270 Kbps of data will produce a bit error rate of 10^{-3} to 10^{-4} at a CNR of 13 dB. Larger size digital carriers for PBX and other business traffic can be transmitted similarly using constant or near constant envelope modulations that produce low adjacent channel interference.

The 1 GHz of bandwidth on the polarization opposite to the video band can be divided into two approximately equal parts, one for subscriber-to-headend links and the other for headend-to-subscriber links. These frequency bands may contain a mix of two-way traffic signals that will substantially depend upon the traffic requirements within the cells. The headends may be connected to the public switched telephone network.

Subscriber transmission will be typically low in power, and would not materially effect other two-way transmitting and receiver systems since there would be frequency offsets and antenna sidelobe isolation. Also use of FM will lead to substantial rejection of interference due to the strong signal capture effect. At the central node the receiving system accepts signals from all the subscriber transmitters. By adjusting the power levels at the subscriber transmitters, all the signals can be received within a dynamic range of 30 dB at the central node.

One important problem in the millimeter wave communication links is the poor frequency stability of RF oscillators as a function of temperature variations. A transmission plan with pilots, Dielectric Resonators, or internal phase-locked oscillators are used to solve this problem. Frequency errors of local oscillators